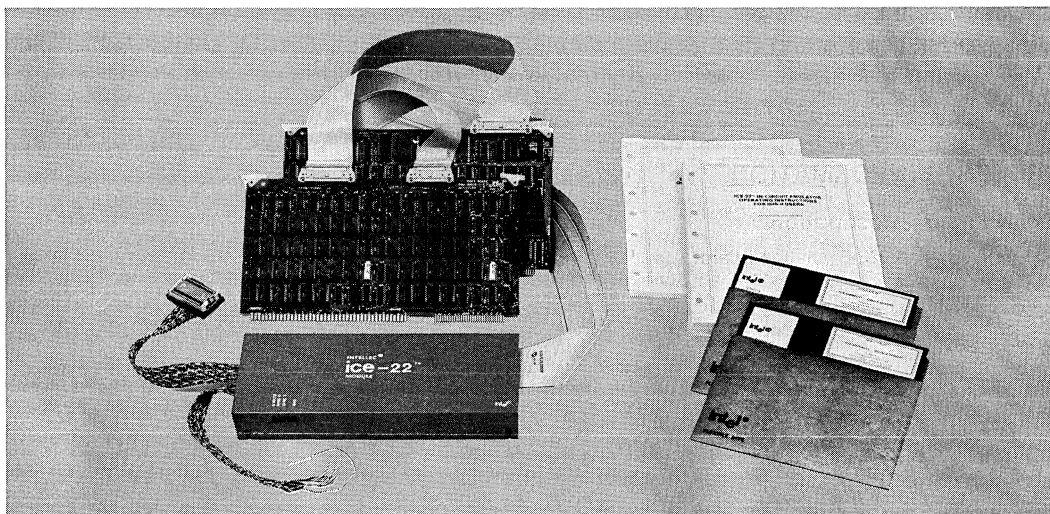




ICE-22™ 8022 IN-CIRCUIT EMULATOR

- Single-line assembler allows mnemonic program instruction changes
- Full symbolic debugging
- ICE™-resident user-program RAM for real-time execution
- Examine and alter 8022 registers, memory, and digital port values, and examine analog port data
- Two user-specified breakpoint registers
- 500 instruction cycle trace
 - conditionally triggered
 - 16 user-definable trace probes
 - symbolic groupings and display
- 32-bit half-microsecond emulation timer
- HELP facility summarizes ICE-22™ command syntax at the console
- User confidence test of ICE-22™ hardware

The ICE-22 module resides in the Intellec® Microcomputer Development System and interfaces to any user-designed 8022 system through a cable terminating in an 8022 emulator microprocessor and a pin-compatible plug. The emulator processor, together with 2K bytes of user-program RAM located in the ICE-22 buffer box, replaces the 8022 device in the user system while maintaining the 8022 electrical and timing characteristics. Powerful Intellec debugging functions are thus extended into the user system. Using the ICE-22 module, the designer can emulate the system's 8022, including full A/D converter function, in real-time or single-step mode. Breakpoints allow the user to stop emulation on user-specified conditions, and a trace qualifier feature allows the conditional collection of 500 instruction cycles of trace data. The ICE-22 trace includes 8022 status information and, through ICE-22 external logic probes, can provide data on up to 16 signal nodes in the user-system peripheral circuitry. For the first time in any ICE module, the designer may alter program memory using ASM-48 mnemonics and symbolic references without returning to ISIS II control. In addition, user-created peripheral chip analyzer routines may be applied to the logic probe data, thereby expanding the in-circuit emulation function to the entire system.



FUNCTIONAL DESCRIPTION

Integrated Hardware/Software Development

The ICE-22 emulator allows hardware and software development to proceed interactively. This is more effective than the traditional method of independent hardware and software development followed by system integration. With the ICE-22 module, prototype hardware can be added to the system as it is designed. Software and hardware testing occur while the product is being developed.

Conceptually, the ICE-22 emulator assists three stages of development:

It can be operated without being connected to the user's system, so ICE-22 debugging capabilities can be used in conjunction with the Intellec text editor and MCS-48™ macro-assembler to facilitate program development before any of the user's hardware is available.

Integration of software and hardware can begin when any functional element of the user system hardware is connected to the 8022 socket. As each section of the user's hardware is completed, it is added to the prototype. Thus, each section of the hardware and software is "system" tested as it becomes available.

When the user's prototype is complete, it is tested with the final version of the user system software. The ICE-22 module is then used for real-time emulation of the 8022 to debug the system as a completed unit, and verify system performance before any ROM codes are entered. A final product verification test may be performed prior to ROM code entry by using the separately available EM-2 8022 emulation board (8022 EPROM equivalent) within the eventual product package.

Thus, the ICE-22 module provides the user with the ability to debug a prototype or production system at any stage in its development without introducing extraneous hardware or software test tools.

Symbolic Debugging

The ICE-22 emulator permits the user to define and use symbolic rather than absolute references to program and data memory addresses; additional symbols are predefined by the ICE-22 software for referencing registers, flags, and input/output ports. Thus, the user need not become involved with machine code, or recall or look up the addresses of key locations in his program as they change with each assembly.

For each symbol that is used for memory reference in an ICE-22 emulator command, the emulator supplies the symbol value location as stored in the ICE-22 emulator symbol table. This table can be loaded with the symbol table produced by the assembler during application program assembly. Furthermore, the user can interactively modify the emulator symbol table by adding new symbols or changing or deleting old ones. This feature provides great flexibility in debugging and minimizes the need to work with hexadecimal values.

Through symbolic references in combination with other features of the emulator, the user can easily:

- Disassemble program memory to mnemonics
- Assemble mnemonic instructions into executable code.
- Examine or modify 8022 internal registers, data memory, or digital port contents.
- Examine analog port data
- Symbolically define groups of user probes, and use these groups to symbolically specify breakpoints and trace qualifiers, or to format external trace data output.

Operation Modes

The ICE-22 software is a RAM-based program that provides the user with easy-to-use commands for initiating emulation, defining breakpoints, controlling trace data collection, and displaying and controlling system parameters. ICE-22 commands are configured with a broad range of modifiers which provide the user with maximum flexibility in describing the operation to be performed.

EMULATION

The ICE-22 module can emulate the operation of a prototype 8022 system, including full emulation of the 8022 analog to digital converter, at real-time speed (0.6 to 3.6 MHz) or in single or multiple steps. Emulation commands to the ICE-22 module control the process of setting up, running, and halting an emulation of the user's 8022-based system. Breakpoints, comparison registers, and tracepoints enable the ICE-22 emulator to halt emulation and provide a detailed trace of execution in any part of the user's program. A summary of the emulation commands is shown in Table 1.

Breakpoints

The ICE-22 hardware includes two breakpoint registers that allow the user to halt emulation when specified conditions are met. The emulator continuously compares the values stored on the breakpoint registers with the status of specified

data, addresses, and/or external logic probes, and halts emulation when this comparison is satisfied. When an instruction initiates a break, that instruction is executed completely before the break takes place. The ICE-22 emulator then regains control of the console and enters the Interrogation Mode. With the breakpoint feature, the user can request an emulation break when his program:

- Executes an instruction at a specific address or within a range of addresses
- Executes a particular opcode
- Receives a specific signal on a logic probe, digital port pin, or group of probes or pins
- Fetches a particular data value from the user program memory

Breakpoints can be composed of conditions on 22 channels which reflect internal 8022 activities, plus the 16 external logic probe channels; all but one of the channels may be specified as "Don't Care" channels. Address ranges must be specified as a range of pages (r00H) to sFFH), a range of 16-byte paragraphs within a page (pr0H) to psFH), or a range of bytes within a paragraph (pqrH to pqSH) where, in each case, s is a digit greater than or equal to the digit r.

Table 1. Major Emulation Commands

Command	Description
GO	Begins real-time emulation and optionally specifies break conditions.
BR0, BR1, BR	Sets or displays either or both Breakpoint Registers used for stopping real-time emulation.
STEP	Begins single-step emulation and optionally specifies terminating conditions.
CR0, CR1, CR2, CR3, CR	Sets or displays comparison criteria in all or individual Comparison Registers used for stopping automatic single-step emulation.
TR	Specifies or displays trace-data collection conditions, and optionally sets Qualifier Register (QR).

Comparison Registers

Four comparison registers are provided that allow the user to halt single step emulation when the single condition specified in any one of these registers is satisfied. The comparison registers differ from the breakpoint registers in that, 1) the comparisons <, ≤, >, ≥, and ≠ are permitted in addi-

tion to the = condition, 2) more 8022 and ICE variables may be compared, and 3) the comparators themselves may be variables.

Trace and Tracepoints

Tracing is used with both real-time and single-step emulation to record diagnostic information in the trace buffer as a program is executed. The information collected includes opcodes executed, program counter and Port 2 values, and 16 logic probe values for the last 500 instruction cycles. (There are one or two cycles per instruction, depending on the particular instruction.) This information can be displayed as assembler instruction mnemonics, if desired, for analysis during Interrogation or Single-Step Mode. The trace-collection facility may be set to run conditionally or unconditionally. One unique trace qualifier, specified in the same way as a breakpoint, governs conditional trace activity. It can be used to condition trace data collection to take place as follows:

- Under all conditions (constantly occurring)
- Only while the trace qualifier is satisfied
- For the 500 instruction cycles preceding the time when a trace qualifier is first satisfied (pre-triggered trace)
- For the next 500 instruction cycles after a trace qualifier is first satisfied (post triggered trace).

INTERROGATION AND UTILITY

Interrogation and utility commands give the user convenient access to detailed information about the user program and the state of the 8022 that is useful in debugging hardware and software. Changes can be made in both memory and the 8022 registers, flags, and digital port values. Commands are also provided for various utility operations such as loading and saving program files, defining symbols and logic probe groups, displaying trace data, controlling system synchronization and returning control to ISIS-II. A summary of the basic interrogation and utility commands is shown in Table 2. Two new emulator features are discussed below.

SINGLE-LINE ASSEMBLER — The single-line assembler (ASM command) is a new in-circuit emulation feature that permits the designer to examine and alter program memory using assembly language mnemonics, without leaving emulation mode or requiring time-consuming program re-assembly. When assembling new mnemonic instructions into program memory, previously de-

defined symbolic references (from the original program assembly, or subsequently defined during the emulation session) may be used in the instruction operand field, and the emulator will supply the absolute address or data values as stored in the emulator symbol table. These features greatly reduce the designer's time spent translating to and from machine code and searching for absolute addresses, with a corresponding reduction in transcription errors.

HELP — The HELP file is a new ICE feature that allows the designer to display ICE-22 command syntax information at the Inteltec console. By typing "HELP", a listing of all items for which help messages are available is displayed; typing "HELP <Item>" then displays relevant information about the item requested, including typical usage examples. The "HELP" listing and a "HELP ASM" message for the ASM command are shown in Table 3.

Table 2. Major Interrogation and Utility Commands

Command	Description
LOAD	Loads user object program (8022 code) into user-program memory, and user symbols into ICE-22 emulator symbol table.
DEFINE/REMOVE	Defines/removes symbols in ICE-22 emulator symbol table.
SAVE	Saves ICE-22 emulator symbol table and/or user object program in ISIS-II hexadecimal file.
LIST	Copies all emulator console input and output to ISIS-II file.
Change/Display Commands	Change or display value of symbolic reference in ICE-22 emulator symbol table, or contents of key-word references (including registers, I/O ports, and status flags), or memory references.
Group Commands	Define, change, remove, or display user-defined logic probe channel groups.
Trace Commands	Position trace buffer pointer; select and format trace output; enable or disable automatic display of trace data and register contents during single-step emulation.
PRINT	Displays trace data pointed to by trace buffer pointer.
Synchronization Line Commands	Set and display enabled/disabled status of SYNC0 and SYNC1 synchronization line outputs or latched inputs (used to allow real-time emulation or tracing to start and stop synchronously with external events).
ASM	Assembles mnemonic instructions into user-program memory, or disassembles and displays user-program memory contents.
INTERRUPT	Simulates external or timer interrupt sequence.
EVALUATE	Evaluates expression and displays resulting value.
SECONDS	Displays contents of emulation timer, in microseconds.
HELP	Displays help messages for ICE-22 emulator command-entry assistance.
EXIT	Terminates ICE-22 emulator operation.

Table 3. HELP Command

*HELP

Help is available for the following items. Type HELP followed by the item name. (For more information about HELP, type HELP HELP.)

Real-Time Emulation:		Trace Collection:	Change/Display/Define/Remove:		
GO GR SY0		TR QR SY1	ASM	REGISTER	DEFINE
BR BRO BR1		<MATCH\$COND>	CBYTE	STACK	REMOVE
<BREAK\$REG>			DBYTE	SECONDS	GROUP
<MATCH\$COND>		Trace Display:	<CHANGE>	<CPU\$REF>	SYMBOL
		TRACE	<DISPLAY>	<ICE\$REF>	
Step Emulation:		OLDEST	State/Mode:		
STEP SR		NEWEST	BASE	ENABLE	SYMBOLIC
CR CRO CR1 CR2 CR3		MOVE	SUFFIX	DISABLE	SYNC
<COMPARISON\$REG>		PRINT	LIST	RESET	
<COMPARISON\$COND>		DUMP			
EVALUATE	<ADDRESS>	<INSTRUCTION>	<PRIMARY>		
EXIT	<ADDRESS\$PARTITION>	<MASKED\$CONSTANT>	<PRIMARY\$10>		
HELP	<CHANNEL>	<MATCH\$GROUP>	<STRING>		
INTERRUPT	<CHANNEL\$PARTITION>	<MATCH\$VALUE>	<SYMBOLIC\$REF>		
LOAD	<EXPR>	<MEMORY\$REF>	<SYSTEM\$GROUP>		
SAVE	<EXPR\$10>	<NUMERIC\$CONSTANT>	<USER\$GROUP>		
	<IDENTIFIER>	<PATHNAME>			

*HELP ASM

ASM - Command to display or change 8022 code memory using assembler instructions.

- (1) ASM <ADDRESS> [TO/LENGTH <ADDRESS>]
(display 8022 code memory as assembler instructions)
- (2) ASM <ADDRESS> =
 <INSTRUCTIONS\$LIST>
 END
(change memory starting at <ADDRESS>)
 Ex: ASM 100 =
 MOV A, 00
 JNZ 100
 END

- (3) ASM <ADDRESS> TO/LENGTH <ADDRESS> =
 <INSTRUCTIONS\$LIST>
 END

(Change several locations and perform range checking or repetition. If the instructions require more memory than the size of the range, an error occurs. If the instructions require less memory, then the data is repeated until the range is filled.)

<INSTRUCTIONS\$LIST> - Standard 8022 instructions typed one per line. The operand "<EXPR>" can be used where "#data" is required, and the operand "<ADDRESS>" can be used where "addr" is required. A continuation prompt ".*" is issued after each carriage return is typed.

SPECIFICATIONS

ICE-22 Operating Requirements

Intellec® Microcomputer Development System (32K RAM required)

System console

Intellec® Diskette Operating System (single or double density) ISIS-II v. 3.4 or later

Equipment Supplied

- Printed circuit boards (2)
- Emulation buffer box, Intellec interface cables, and user-interface cable with 8022 emulation processor
- 16 external trace probes
- Synchronization cables
- Crystal power accessory
- Operating instructions manual
- Diskette-based ICE-22 software (single and double density)

Emulation Clock

User's system clock (0.6 to 3.6 MHz) or ICE-22 crystal power accessory (3.0 MHz)

Environmental Characteristics

Operating Temperature: 0° to 40°C

Operating Humidity: Up to 95% relative humidity without condensation.

Physical Characteristics

Printed Circuit Boards

Width: 12.00 in. (30.48 cm)

Height: 6.75 in. (17.15 cm)

Depth: 0.50 in. (1.27 cm)

Buffer Box

Width: 4.5 in. (11.43 cm)

Length: 10.0 in. (25.40 cm)

Depth: 1.25 in. (3.18 cm)

Packaged Weight: 8.0 lb (3.63 kg)

Electrical Characteristics

DC Power Requirements

$V_{CC} = +5V, +5\%, -1\%$

$I_{CC} = 13.2A \text{ max; } 11.0A \text{ typical}$

$V_{DD} = +12V, \pm 5\%$

$I_{DD} = 0.1A \text{ max; } 0.05A \text{ typical}$

$V_{BB} = -10V, \pm 5\%$

$I_{BB} = 0.05A \text{ max; } 0.01A \text{ typical}$

ORDERING INFORMATION

Part Number Description

MCI-22-ICE	8022 Microcontroller In-Circuit Emulator, cable assembly and interactive diskette software
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